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SOCIAL, POLITICAL, AND ECONOMIC FACTORS RESPONSIBLE FOR THE REEMERGENCE OF TRICHINELLOSIS IN SERBIA: A CASE STUDY

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ABSTRACT: Over the past decade, eastern Europe has experienced a resurgence of trichinellosis. A recent outbreak in Serbia, Yugoslavia, from December 2001 to January 2002, involving 309 people, revealed many of the causes for this reemergence. Epidemiological investigations indicate that the immediate cause of the recent outbreak was the consumption of smoked sausages produced by a small slaughterhouse or meat processor. However, failure of in-house meat inspection procedures and quality assurance as well as oversight by official veterinary control were also responsible. Further analysis of this breakdown in the food safety net revealed additional general factors that have yielded a seriously deficient veterinary control system, and these are factors that are relevant to the problems experienced throughout eastern Europe and other regions. The recent civil war that led to the breakup of the former Federation of Yugoslavia resulted in severe economic and demographic changes, including high inflation and external economic sanctions. This led to (1) the loss of large numbers of experienced veterinary control officers and their replacement with inexperienced personnel, (2) a change in the swine industry with reduction in the number of large establishments with in-house inspection and replacement with more than 1,000 small abattoirs, too small to afford full-time in-house inspection, and (3) an increase in smallholder pig farming with reduced government oversight to ensure high standards in pig-rearing practices (infection risk management). The consequences of these events have been a 300% increase in Serbian pig infection and a concomitant large increase in human outbreaks. Before 1990, swine trichinellosis in Serbia was confined to 4 small districts, but today about one third of the Republic is considered endemic for trichinellosis. The reemergence of trichinellosis in Serbia illustrates the ability of this zoonosis to “leak” through a poorly maintained food safety barrier and the vulnerability of effective veterinary control to national and international events.

Trichinellosis is 1 of the oldest recognized parasitic zoonoses and has long been the target of intensive efforts to eliminate it from the human food chain, particularly in Europe (Campbell, 1983; Nöckler et al., 2000; Blancou, 2001). Throughout most of the 20th century, the various approaches to control were successful in Europe, North America, and the former U.S.S.R. However, during the 1980s and 1990s, a resurgence of trichinellosis occurred in many of these regions (Dupouy-Camet, 2000; Pozio, 2001). Recently, Murrell and Pozio (2000) detailed the complex interplay of social, political, and biological factors responsible for the reemergence of trichinellosis, factors similar to those described by Daszak et al. (2000) for emerging infectious diseases of wildlife with zoonotic potential. Human activities are often the major forces inducing alterations in the host–parasite equilibrium.

The interplay of these events and changes has been profound in eastern Europe, especially in the Balkans. In Bulgaria, from 1922 to 1974, only 38 outbreaks of trichinellosis occurred, but from 1991 to 2000, 96 outbreaks were recorded, involving 5,683 people (Kurdova, 2001). In Romania, the prevalence of infection since 1983 has increased 17-fold, to 16,712 cases in 1990–1999 (Olteneau, 2000). The recent civil war leading to the breakup of the former Republic of Yugoslavia has had catastrophic effects on the veterinary public health control of trichinellosis in the former states. Before the war, Croatian authorities recognized only a few endemic (village) locations (Marinculic et al., 2001), related primarily to the free-range grazing of pigs (Rapic et al., 1984). However, today, trichinellosis is considered the country’s most important concern for food safety. For example, in the District of Vukovar, near the northern border with Serbia, a prewar swine prevalence of 0.05% was reported, but now based on recent serosurveys, this prevalence has increased to 33% in some locations (Marinculic et al., 2001).

In the Republic of Serbia, which, along with Montenegro, now constitutes Yugoslavia, the effects of the war on trichinellosis have also been drastic. As reported by Cuperlovic et al. (2001), trichinellosis is now the most serious food-borne parasitic disease in Serbia. Before the war, the implementation of mandatory meat inspection and the improvement in swine production practices had cut the swine trichinellosis incidence from 0.11% in 1918 to less than 0.009% in the 1980s; human cases had also declined markedly (Cuperlovic et al., 2001). However, after the dissolution of the Federation, the prevalence of infection in inspected pigs has increased nearly 300% from 1994 to 1999, and the annual number of human cases has increased 2- to 4-fold (559 cases in 1999) (Murrell and Pozio, 2000). The trace-back to Serbia of exported horses responsible for large outbreaks of horse-meat trichinellosis in France and Italy, totaling 800–1,000 people, has compounded this problem (Boireau et al., 2000; Pozio et al., 2001).

Recently, a large human outbreak caused by Trichinella spiralis–infected pork sausage occurred in Serbia. The epidemiological investigation of this outbreak revealed a number of causal factors that have contributed to the reemergence of trichinellosis. We report in this study the details of this outbreak and relate the recent breakdown of prevention and control measures to underlying political, socioeconomic, and demographic forces that are responsible factors.

MATERIALS AND METHODS

Outbreak area

The outbreak occurred between 20 December 2001 and 21 January 2002 in the town of Zrenjanin, 75 km northeast of Belgrade, located in the Autonomous Province of Vojvodina, Republic of Serbia. The outbreak was first detected on 20 December and confirmed on 31 Decem-

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ber 2001. The majority of the 309 cases from this single-source outbreak were diagnosed in the Department of Infectious Diseases, General Hospital “Dr. Djordje Joanovic,” Zrenjanin; the patients were from several communities of the Zrenjanin District (Zrenjanin, Novi Becej, Zitiste, and Nova Crnja). Three cases were diagnosed at the Health Center “Kosta Sredojev-Sljuka” General Hospital, Kikinda, 4 cases at the Public Health Institute of Montenegro, Niksic. The remaining 19 of the 309 cases were soldiers who were diagnosed at the Military Medical Academy, Belgrade. The last case was reported on 21 January 2002.

Diagnostic methods

Human cases were diagnosed by (1) epidemiological analysis (food sources, food preparation, etc.), (2) clinical recognition of the syndrome of acute signs and symptoms of trichinellosis (Bruschi and Murrell, 2001), and (3) laboratory tests that included differential blood counts, evaluation of albumin levels in sera, and evaluation of the enzymes lactate dehydrogenase, CPK, and transaminase and were confirmed serologically by fluorescent antibody test (FAT) (Ivanoska et al., 1989). Diagnosis of infection required criteria (2) or (3) (or both) and support from (1). The 19 soldiers were serologically tested in the Military Medical Academy by both FAT and enzyme-linked immunosorbent assay (Mikic et al., 1996).

The source of the infection was a domestic smoked sausage produced and distributed by a slaughterhouse located in Kumane, a village adjacent to Zrenjanin. The abattoir slaughtered up to 100 swine per day. The thermal processing of the products was performed in a smoking chamber by heating wood, without control of temperatures. Samples of the implicated sausage were examined for trichina by the standard pepsin-digestion method (Gamble et al., 2000) carried out at both the Specialized Veterinary Institute of Zrenjanin, the Institute for Meat Technology and Hygiene in Belgrade, and the WHO/FAO Collaborating Centre for Parasitic Zoonoses, Royal Veterinary and Agricultural University, Frederiksberg, Denmark. At the latter laboratory, for example, 8 g of sausage was digested in 1% pepsin-1% HCl at 37 °C for 7.5 hr, and the larvae were recovered by several washing and settling steps. Approximately 3.5 g of fat was also recovered; therefore, the number of larvae recovered was divided by 4.5 g to determine the larvae per gram of muscle. Species determination of the Trichinella larvae recovered from the sausage samples was also performed at the WHO/FAO Collaborating Centre, using the Trichinella multiplex polymerase chain reaction (PCR) procedure (Zarlenga et al., 1999).

Data sources and classification

Retrospective data on annual human and swine infections were obtained from the Public Health Institute of Serbia, Belgrade, the Federal Department for Statistics, Belgrade, the Commission for Trichinellosis, Ministry of Agriculture, Forestry and Water Supply, Belgrade, and the Ministry of Health of the Republic of Serbia, Belgrade.

Officially supervised meat inspection data in Serbia are classified according to the type of farming system producing the pigs. (1) Slaughterhouse pigs—swine slaughtered at establishments that are under veterinary control and, therefore, receive compulsory inspection. The sources of pigs are normally from large industrial farms or private farms with 100 or more pigs. A few pigs originating from smaller production units are passed through this inspection stream each year; these are usually surplus pigs from production intended for the owner’s personal use. (2) Farm pigs—swine produced by small-farm operators and slaughtered on the farm premises for domestic use. Regulations require compulsory inspections for such farm-slaughtered pigs if originating in the Ministry of Agriculture-declared Trichinella endemic communities.

RESULTS

Description of the outbreak

The first cases arising from the Zrenjanin outbreak were encountered on 20 December 2001 at the Department for Infectious Diseases of General Hospital “Dr. Djordje Joanovic,” Zrenjanin; new cases stemming from this outbreak were identified weekly through 21 January 2002 (Fig. 1). A total of 309 cases were reported, all originating from the same infection source.

The frequency of infection by sex and age is presented in Table I based on the data available (no data could be obtained on 30 cases). The male to female infection ratio was 1.65:1. However, there was no age difference between the sexes.

Seventy-four infected people were hospitalized in either the General Hospital “Dr. Djordje Joanovic,” Zrenjanin, or the Military Medical Academy, Belgrade. Thirteen of the patients (all in the Zrenjanin Hospital) had neurological complications. Two patients developed pneumonia, and 2 patients experienced cardiac disturbances. No death occurred.

Interviews of patients led to a common source—smoked pork sausage produced by a slaughterhouse near Zrenjanin. Attempts to trace the pork to the farm of origin were unsuccessful.

Treatment

All patients were treated with mebendazole, administered in 100-mg tablets 3 times a day for 14 days. Hospitalized patients with severe symptoms received corticosteroids.

Parasitological data

Pepsin digestion of 50 g of the implicated smoked sausage at the Institute for Technology and Hygiene yielded 19 larvae per gram of sausage. The confirmatory exam at the WHO/FAO Collaborating Centre yielded 23 larvae per gram. The PCR typing identified the recovered larvae as T. spiralis.

Slaughterhouse investigation

Epidemiological investigation by staff of the Institute of Meat Technology and Hygiene identified the abattoir that produced the smoked sausage. The investigation uncovered a number of flaws in the proprietor’s in-house meat inspection process. Although the slaughterhouse employee assigned the task of meat inspection for Trichinella sp. had received 10 days training in the enzymatic digestion of meat at the Veterinary Faculty in Belgrade, she had failed to correct serious problems that arose in practice. These included failure to adequately clean the sieves (sieves were more than 50% obstructed) and gross deviations from the prescribed protocol for settling and separation...
Table I. Age and sex of trichinellosis patients.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age 5-9</th>
<th>Age 10-19</th>
<th>Age 20-29</th>
<th>Age 30-39</th>
<th>Age 40-49</th>
<th>Age 50-59</th>
<th>Age 60+</th>
<th>Total</th>
<th>% of total cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>6</td>
<td>16</td>
<td>32</td>
<td>33</td>
<td>38</td>
<td>18</td>
<td>24</td>
<td>167</td>
<td>59.9</td>
</tr>
<tr>
<td>Female</td>
<td>2</td>
<td>8</td>
<td>19</td>
<td>17</td>
<td>28</td>
<td>19</td>
<td>19</td>
<td>112</td>
<td>40.1</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>24</td>
<td>51</td>
<td>50</td>
<td>66</td>
<td>37</td>
<td>43</td>
<td>279</td>
<td>100.0</td>
</tr>
</tbody>
</table>

of digestion products, i.e., larvae. The proprietor is now being prosecuted. The district government veterinary inspector is also being charged with neglect of official responsibilities for failing to provide inspection quality assurance.

Retrospective analyses of swine and human trichinellosis in Serbia for the period 1990–2001

The reemergence of swine trichinellosis in Serbia during the 1990s is demonstrated in Figure 2, which presents reported annual infection data for pigs receiving veterinary inspection during this period. In contrast to these prevalences (0.06–0.16%), slaughterhouse inspection data for Serbia during the prewar 10-yr period of 1980–1989 showed that the prevalence in swine had fallen to 0.009% (Cuperlovic, 1991; Djordjevic, 1991). Because data on swine infection for the 1990–1993 period are fragmentary and imprecise (wartime conditions), they were not included in this analysis. Increases in infection rates during 1994–2001 were especially high among the farm-inspected swine, although an increase also occurred among swine inspected at slaughterhouses (3- to 4-fold between 1995 and 2000). At the peak year of 2000, the number of infected pigs detected overall by veterinary inspection, based on a total slaughter of 3 million pigs, was 6,700. The major risk sector is the production of farm pigs, which have consistently had very high infection and are not under comprehensive veterinary control. The Republic Veterinary Inspection Services (Ministry of Agriculture, Forestry and Water Supply) estimate that, currently, about 750,000 swine annually do not receive veterinary inspection just before slaughter.

The annual number of human cases (1990–2000) in Serbia parallels that of infected pigs detected at slaughter (Fig. 3), indicating that a significant number of infected pigs for human consumption were not detected.

Areas of high risk

Current areas of highest swine infection represent nearly one third of the country (Fig. 4). Before 1990, only 4 districts were considered endemic: Sid, Stremsha Mitrovica, Sabac, and Kladovo. These endemic districts are also the areas from which a high proportion of human outbreaks are reported: Vojvodina (West and South Backa, South Banat, Srem), Macva, Stig, Zvzid, and Kljuc, including the regions adjoining the river villages of the Sava, Danube, Morava, and Drina. The increase in
Map of trichinellosis endemic districts of Serbia (scale 1:1,250,000). Shaded districts are current endemic districts. Districts outlined in heavy lines were designated endemic before 1990.
the incidence of trichinellosis in the Province of Srem bordering the Vukovar District of Croatia after the civil war is especially large (Cuperlovic et al., 2001; Marinculic et al., 2001).

**DISCUSSION**

The Zrenjanin outbreak exhibits many features typical in trichinellosis outbreaks. The occurrence in December and January is a common feature in the Northern Hemisphere and reflects increased pig slaughter for local consumption during Christmas and winter, especially pork sausages, salami, and smoked meat (Murrell and Pozio, 2000; Dubinsky et al., 2001). The density of *T. spiralis* in the sausage responsible for the Zrenjanin outbreak, approximately 20 larvae per gram, was sufficient to cause clinical illness; a modest 100-g serving would provide an inoculum of about 2,000 larvae, although the processing of the pork for sausage probably kills some proportion of the larvae. The exposure level was sufficient to require hospitalization of 74 of the patients.

The case report history (Fig. 1) suggests that initial infections occurred sometime in early to mid-December 2001. Typically, the disease incubation period ranges from 7 to 30 days depending on the severity of infection (Kociecka, 2000; Bruschi and Murrell, 2001). The peak in new cases in the third week of the outbreak indicates that most patients were infected around the Christmas–New Year holiday period, the interval often associated with the consumption of special sausages and salami. The higher prevalence of infection among adult males is not unusual in trichinellosis outbreaks (Schenone et al., 1997; Charkit, 1998). For example, in a recent outbreak in Slovakia, 70% of the cases occurred in males between 21 and 50 yr (Dubinsky et al., 2001). This skewed distribution may be related to social or behavioral patterns between sexes rather than to biological factors, i.e., resistance or tolerance.

The immediate causes of this outbreak are slaughterhouse-related professional and technical errors and failure of veterinary quality control, factors that are frequently encountered in pork-related outbreaks (Forbes and Gajadhar, 1999). The technical incompetence of the slaughterhouse employee, the owner’s failure to provide proper supervision, and the lack of control by official veterinary officers were all factors contributing to the weakening of the food safety system. These problems are consistent with those of many countries that previously had a high degree of veterinary public health success in controlling trichinellosis (Dupouy-Camet, 2000; Cuperlovic et al., 2001; Murrell, 2001; Oltenea, 2001). The basic causes are similar to those described by Morse (1995) and Daszak et al. (2000) for the emergence of infectious diseases and include political, socioeconomic, and demographic changes. All these have had a marked effect on Serbia’s veterinary public health infrastructure.

The linkage between these influences and the control of trichinellosis is complex. During the past 12–13 yr, Yugoslavia has experienced war, political upheaval, and international economic sanctions. The consequences have resulted in a severe decline in national income and extremely high inflation. This has severely affected the veterinary inspection system, chiefly through the loss of experienced veterinary inspectors due to inadequate salaries (US$30–50 per month). Many of these trained and experienced professionals have either found other positions or have emigrated, forcing the government to recruit and assign newly graduated veterinarians, often with little or no experience or training in veterinary inspection. Because of the failure of the government to provide adequate training, this problem continues.

A related factor is the decline in number of large intensive or industrial slaughterhouses; many have been forced to close because of financial hardship. Formerly, the quality of veterinary control in these large establishments was generally high. In their place, nearly 1,000 smaller privately owned abattoirs or meat-processing plants have appeared. These are usually too small to justify a full-time in-house government inspector, and this, along with the inability of the veterinary control regulatory agency to provide the required level of quality assurance, has created a serious food safety risk.

The veterinary control system of Serbia is responsible for enforcing animal husbandry and marketing regulations, which are designed to prevent infections in the swine herds. The nature and quality of animal feed, e.g., presence or absence of meat scraps, strict rodent control, prevention of animal cannibalism, application of identity markings to pigs (for trace-back purposes), and prevention of clandestine marketing and slaughter of pigs, are all areas that require much attention. Although official regulations require compulsory inspection of home-slaughtered swine in the declared endemic areas, it is apparent that this has not been enforced adequately.

A further consequence of this breakdown in veterinary control and in farming practices is the threat of spillover of *T. spiralis* into wildlife and the creation of reservoir hosts (Murrell et al., 1987; Pozio, 2000). This is an issue that needs urgent attention in the endemic areas; a similar situation has evolved with wild boar reservoirs in neighboring Croatia (Marinculic et al., 2001).

In summary, the Zrenjanin outbreak described in this study reflects the outcome of complex interacting events that can damage a control system for a zoonosis such as trichinellosis. The political turmoil in Yugoslavia led to economic and social disruptions that have adversely affected the country’s veterinary control infrastructure. This, coupled with the economic forces that have altered the meat production and processing system, including the creation of many poorly managed small pig-rearing operations, and the loss of experienced food safety professionals have produced a breakdown in trichinellosis control (Figs. 2, 3). The rapid reemergence of trichinellosis in this environment underscores the fact that this zoonosis is an opportunist, able to exploit new agricultural, human, social, and behavioral conditions that lead to compromised control programs (Murrell and Pozio, 2000). Effective trichinellosis control in Serbia will, in large part, be dependent on improving the political and economic conditions at the national (and international) level.

**LITERATURE CITED**


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